VIBRATION TEST EQUIPMENT

Series 600

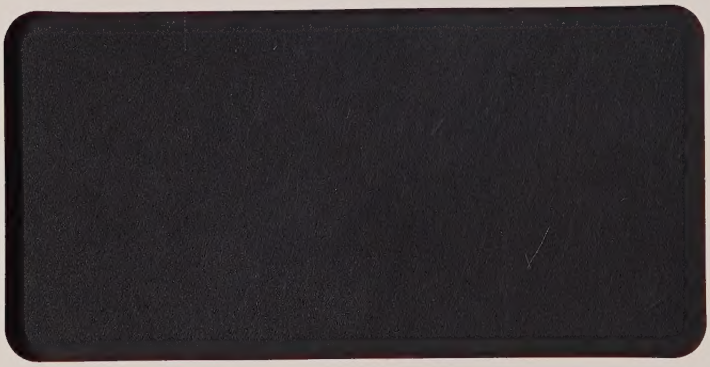
TRANSDUCER

CALIBRATION SYSTEM

MP MASTER

MA34559

UNHOLTZ-DICKIE CORPORATION



Series 600

TRANSDUCER

CALIBRATION SYSTEM

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UNHOLTZ-DICKIE CORPORATION

VIBRATION TEST EQUIPMENT

MODEL 600 SERIES

DIGITAL TRANSDUCER CALIBRATION SYSTEM

---------- FEATURES ----------

- Fast, computer-controlled calibration of accelerometers and velocity transducers with 400AT/C Calibration Control System.
- Simple, user-friendly calibration test setup, calibration measurement, data storage and retrieval using PC AT* Compatible Host and UD370 Calibration Control.
- Complete keyboard control of calibration, with all instrument settings automatically determined.
- Precision sinusoidal comparison technique allows excellent diagnostics for recognizing faulty accelerometers.
- One shaker with a three lb. armature provides excellent low frequency waveforms, and low transverse vibrations even with large transducers.

---------- PERFORMANCE ----------

- Frequency ranges from 2 to 5000 and 4 to 10000 Hz using swept-frequency or stepped-frequency for charge or voltage calibration of accelerometers.
- Excellent low frequency resolution - typically 0.3%.
- Controlled acceleration levels from 0.1 to 100 g with low noise and distortion.
- Charge and voltage calibration of accelerometers from 0.01 to 10000 pC/g or mV/g.
- Frequency range for velocity transducer calibration from 5 to 5000 Hz.
- Controlled velocity levels from 0.1 to 50 in/s.
- Velocity transducer sensitivities calibrated from 0.1 to 10000 mV-s/in.
- Fully-annotated color displays of graphical and tabular data.
- Variety of printers provides calibration certificate in either color or black on white.
- Calibration transfer accuracy at reference frequency better than ±1%.

* PC AT is a trademark of the IBM Corp.

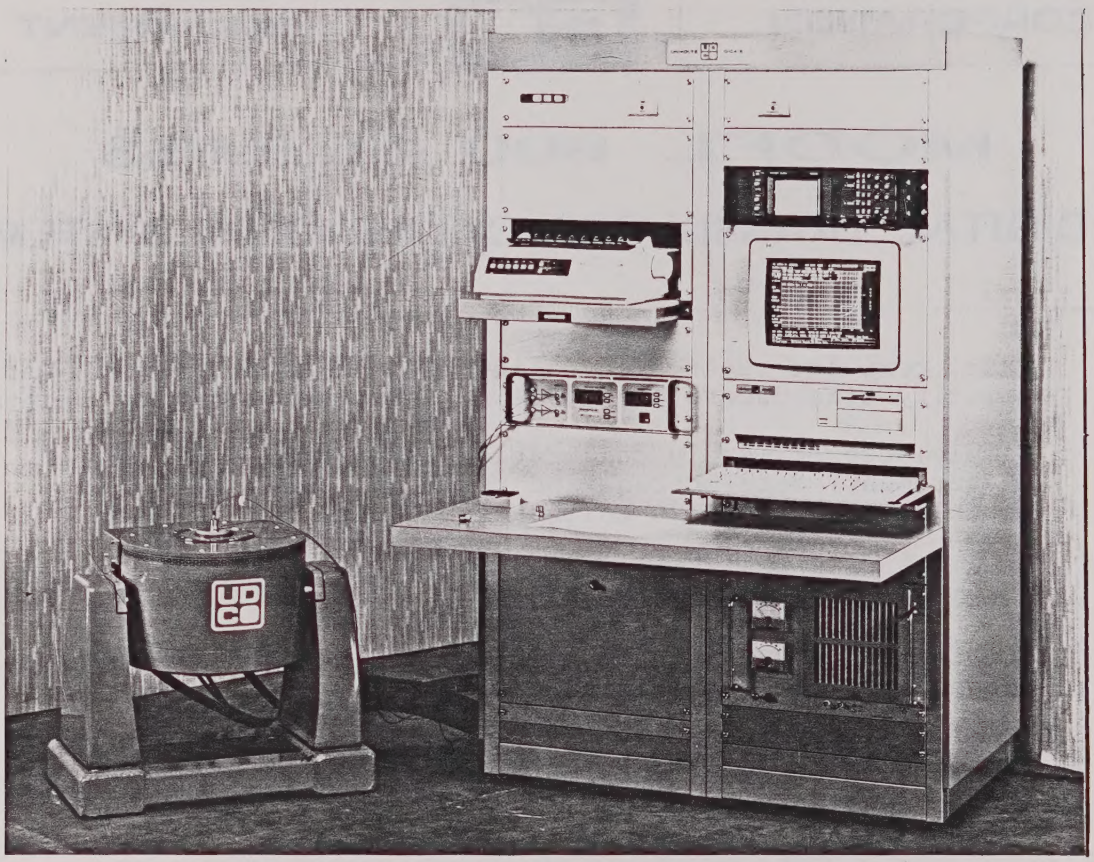


Fig.1a Model 650 Digital Transducer Calibration System

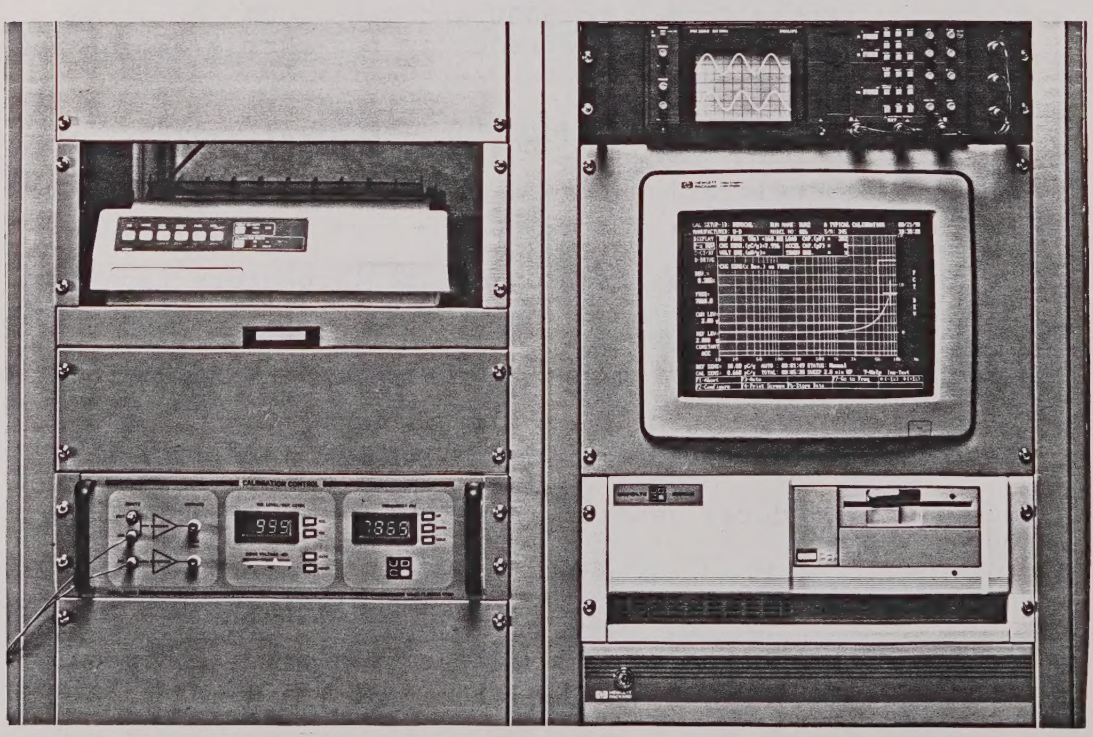


Fig.1b Model 400AT/C Components

General Description

The Series 600 Digital Transducer Calibration Systems provide an integrated collection of components necessary to provide quick and accurate calibration of accelerometers and velocity transducers over a wide range of frequency and vibration amplitudes. The Series 600 Systems utilize a Model 400 AT/C Calibration Control System which contains a PC AT compatible host computer with accessories and a Model UD370 Calibration Control. The remaining components of a 600 Series System are a UD shaker and power amplifier, usually the Models 106A and TA100A-C respectively. A two-bay console with writing surface is arranged to house the electronic components. The complete system is shown in Figs. 1a and 1b.

The functioning of the 400AT/C is similar to that of the standard 400AT/S Sine Control System. The PC AT host provides menu-driven control over the UD370 by establishing parameters entered at the keyboard, for initiating and monitoring calibration tests, including verification of the accelerometer standards. It also provides hard copy calibration certificates via the printer, storage of calibration setups and calibration test data via the hard disk, and also supplies a library of applicable manufacturers' data for different transducers.

The UD370 digitally generates an extremely low-distortion sine wave in the oscillator section. The frequency of this sine wave may be swept or stepped, depending on the needs of the operator. The servo section provides a continuously adjusted voltage amplitude to the power amplifier to provide a constant vibration amplitude vs frequency. The vibration input section of the UD370 contains calibration grade electronics suitable for comparing the amplitude of the vibration signal of the unknown channel containing the device-under-test with that of the reference channel.

Calibration Principle

The working standard accelerometer (UD Model 8B6-reference) and the device-under-test (DUT-Unknown) are mounted on opposite sides of the ceramic center insert for the table of a UD Model 106A Shaker. This provides excellent electrical isolation of the transducers as well as exceptionally stiff coupling for back-to-back mounting. The top surface of the ceramic insert is flush with the top of the shaker table allowing excellent accessibility to the DUT, and also necessary protection for the working standard and its cable connection. This has been an attractive feature of earlier UD automatic calibration systems as well.

The UD370 contains a precision charge amplifier with frequency compensation for the Reference Channel and a host-selectable precision charge amplifier or voltage amplifier for the Unknown (DUT) channel, as shown in Fig. 2. The frequency compensation for the Reference Channel has been adjusted by a comparison procedure with the laboratory standard accelerometer (UD Model 8B6) and its associated NIST calibration data to provide a constant working reference sensitivity to 10 kHz. This calibration comparison is verified periodically by the 400AT/C.

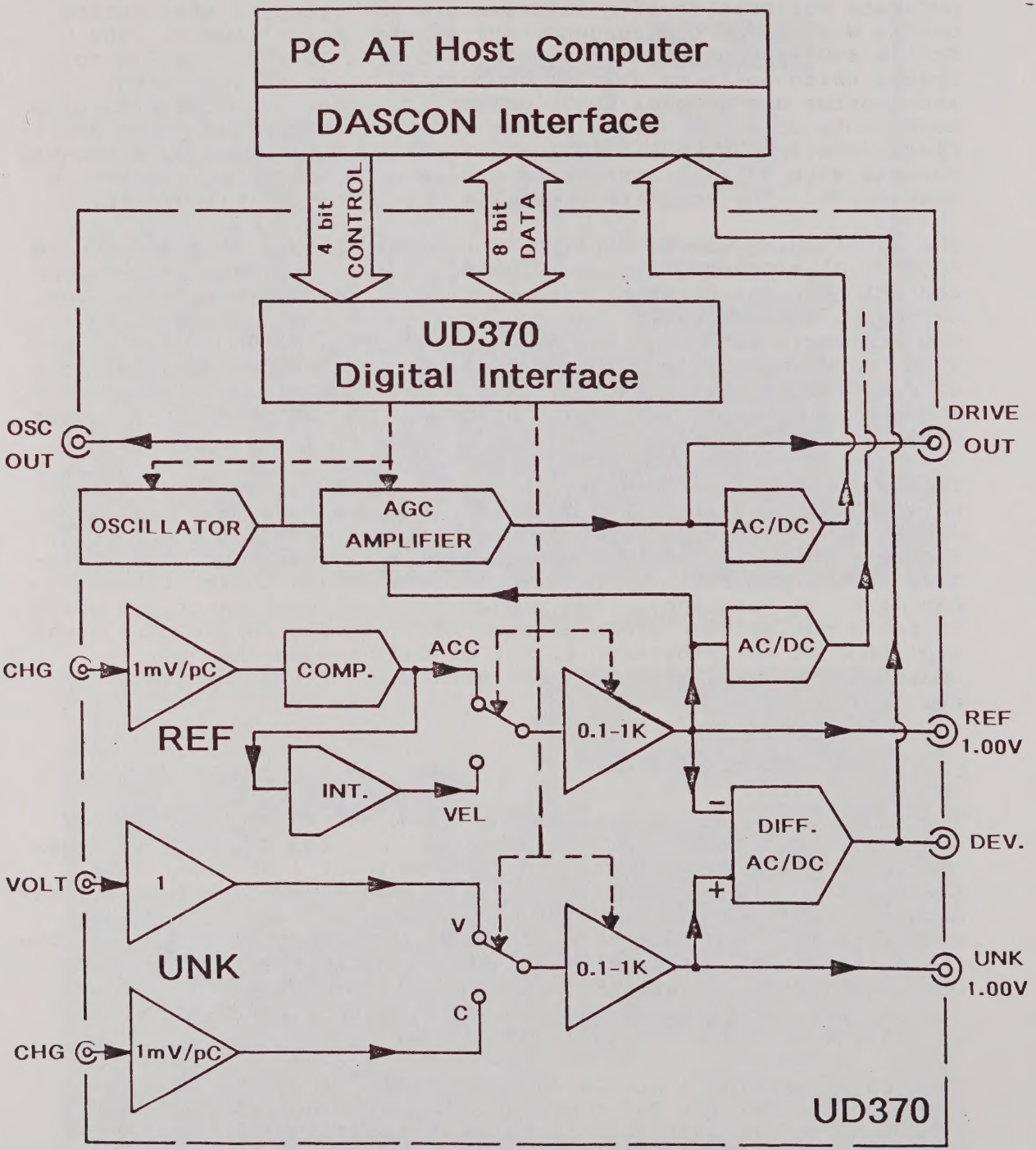


Fig. 2

SIGNAL FLOW DIAGRAM - Model 400AT/C

A precision comparison technique is also used to calibrate the DUT. Both precision input amplifiers are followed by identical precision wide-range adjustable-gain amplifiers. When the test is started, the PC AT host sets the gain of the reference post amplifier to provide 1.00 V peak control voltage to the input of the servo control section of the UD370 at the acceleration calibration level and the reference frequency. The outputs of both adjustable-gain post-amplifiers are connected to a precision low-drift differential AC to DC converter.

When the system reaches the calibration test level, the DC output of the converter is monitored by the PC AT Host, and an iterative software routine causes the gain of the unknown channel amplifier to be adjusted until a minimum or null voltage appears at the output of the differential AC-DC converter. The sensitivity of the DUT is calculated and displayed on the video monitor by utilizing the known gain of the unknown channel and the parameters of the reference channel. The gain resolution of both amplifiers and small deviations of the null voltage from zero are used in the computation for unknown sensitivity to eliminate errors due to the discrete nature of the gain settings.

Following the sensitivity measurement at the reference frequency, the gain settings of both amplifiers are maintained and the deviation of the sensitivity of the DUT from its sensitivity at the reference frequency is shown graphically on the video monitor for a swept-frequency test, or shown in a table for a set of stepped frequencies. Both alternatives are shown in Figs. 3 and 4. Note the documentation of the test parameters around the borders of the data graph or data table. A cursor is available for the data graph to investigate DUT sensitivity values at different frequencies.

For velocity transducer calibrations, an electronic integrator circuit is automatically inserted in the Reference channel, which also provides the amplitude control. The DUT is connected to the voltage input of the UD370, and the measurement procedure for the resulting velocity signal is the same as that for acceleration signals.

Simple Calibration Test Setup

The test setup parameters are entered at the keyboard through a simple menu-driven setup procedure. A typical calibration test setup includes identification of the transducer manufacturer and model number, the nominal sensitivity of the transducer, manufacturer's specifications for the sensitivity and frequency response tolerances, the vibration test level, the sweep frequency limits (or the discrete calibration frequencies), sweep direction, sweep type and sweep time. The test setup is stored on the hard disk and may be run at any time for a particular sensor. The numerical parameters may be recalled and edited at any time.

The test setup serves as the reference library for manufacturer's data, as well as the source of parameters for the actual calibration test. The library is extended by creating new test setups for other accelerometer types.

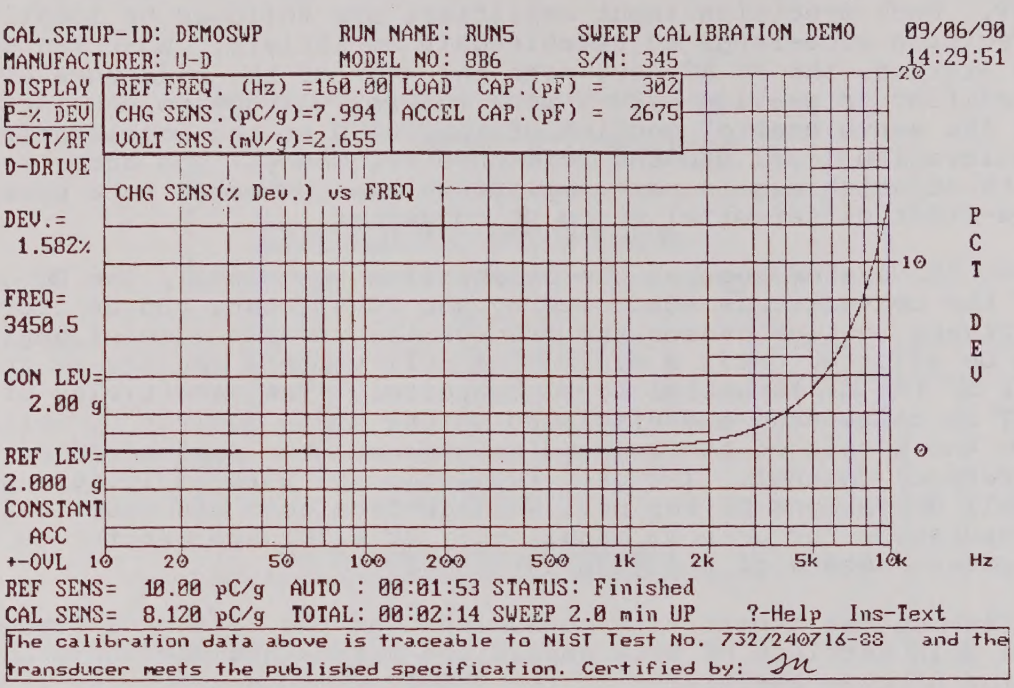


Fig. 3 Swept Frequency Calibration

[approx. 65% full size]

CAL.SETUP-ID: DEMOSTEP RUN NAME: RUN2 STEPPED-FREQUENCY DEMO. 09/21/90
MANUFACTURER: U-D MODEL NO: 886 S/N: 345 10:34:29

DISPLAY

REF FREQ. (Hz) =160.00
CHG SENS.(pC/g)=7.994
VOLT SNS.(mV/g)=2.656
LOAD CAP.(pF) = 302
ACCEL CAP.(pF) = 2675

DEV.= %

FREQ= 159.2

CON LEV= 2.02 g

REF LEV= 2.000 g

CONSTANT ACC

FREQ. (Hz)	DEV (%)	SENS (pC/g)	FREQ. (Hz)	DEV (%)	SENS (pC/g)
159.8	0.00	7.994	400.2	0.02	7.995
			500.4	0.03	7.996
10.0	0.13	8.004	699.9	0.13	8.004
15.0	0.11	8.003	850.6	0.15	8.006
20.0	0.16	8.007	999.9	0.18	8.008
30.0	0.06	7.999	1499.5	0.33	8.020
40.0	0.05	7.998	2001.4	0.56	8.039
50.0	0.03	7.996	2999.7	1.23	8.092
70.0	-0.01	7.993	3501.5	1.65	8.126
85.1	0.00	7.994	4001.0	2.15	8.166
100.0	-0.01	7.993	4500.0	2.73	8.212
160.2	0.00	7.994	4999.9	3.36	8.262
200.3	0.00	7.994	5500.1	4.08	8.320
299.7	0.14	8.005	6000.9	4.85	8.382

FREQ. (Hz)	DEV (%)	SENS (pC/g)
6500.3	5.69	8.449
6999.0	6.60	8.522
7499.7	7.58	8.600
7999.2	8.63	8.684
8500.1	9.75	8.774
9001.6	10.95	8.870
9499.8	12.23	8.972
9998.2	13.58	9.080

REF SENS= 10.00 pC/g AUTO : 00:01:21 STATUS: Finished
CAL SENS= pC/g TOTAL: 00:05:56 ?-Help Ins-Text
The calibration data above is traceable to NIST Test No. 732/240716-88 and the transducer meets the published specification. Certified by:

Fig. 4 Stepped Frequency Calibration

Running the Calibration Test

The calibration test is initiated by entering the appropriate setup ID name, a run name or a default entry, the serial number of the accelerometer, answering a query relative to saving data automatically, and then pressing a single function key. As shown in Figs 3 and 4, the calibration data is shown either in graphical or tabular form on the high resolution VGA color display.

The calibration data at the reference frequency is shown in a box at the top of the graph (or table). The sweep calibration data is presented on the graph in Fig. 3 with the cursor sweeping across. The axes of the graph are completely labeled and scaling may be changed at any time to view critical areas or to provide a better presentation. The test parameters, including transducer details, date and time are located around the periphery of the graph.

At any time, the drive voltage or the control level may be viewed by key command. In addition the sweep may be halted or reversed, or the test frequency may be manually shifted up or down or shifted to another value between the test limits. Other function keys provide a full 8 1/2 x 11 inch print of the video screen using the dot matrix printer, and also storage of the data on the hard disk.

Values for the cursor position during the sweep and during manual control are shown on the periphery of the graph. Data points after the test is over can also be examined using the cursor. For piezoelectric accelerometers, a complementary measurement may be made at the reference frequency after the sweep is over to determine the voltage sensitivity and the accelerometer capacitance, if charge sensitivity were initially measured. If desired, a table of calibration values at various frequencies may be specified and displayed. Data smoothing is also provided by key command.

If stepped-frequency calibration is specified in the test setup, a graph of the stepped-frequency data may be obtained by function key command after the test has finished. Manual control may also be asserted during the test, and the frequency controlled by the arrow keys. Data during manual control is always displayed on the periphery of the table, but may be displayed permanently on the table by function key command.

The manual mode of operation allows detailed inspection of accelerometer performance, if desired.

Graphics, Hard Copy and Data Storage

As mentioned previously, the graphics are in full color, and at any time the graphic display may be printed by function key command.

As in other 400AT Control Systems, the dot matrix printer rotates the screen 90° and prints a full 8 1/2 x 11 inch black-on-white copy. Data may be saved onto the hard disk at any time during the test by function key command, and also saved automatically at the end of the test by appropriately responding to a query when initiating the test. A color printer is available as an option,and prints 2 half-page non-rotated graphs on an 8 1/2 x 11 inch page.

Menu-driven listing of saved data provides easy retrieval from the hard disk because the TEST ID is associated with the manufacturer and model designation of the sensor and the TEST RUN ID is associated with the serial number. Changing the scaling of the graphics, using the cursor to examine individual data points and producing other data manipulations can also be accomplished for saved data.

System Verification

Periodically, the operator uses the laboratory standard accelerometer as the DUT and obtains a comparison between the sensitivities of the laboratory standard and the working standard. A test setup with the first three symbols in the ID being STD is used, and it contains all the pertinent information about the working standard and laboratory standard accelerometers along with the NIST-referenced sensitivities at the NIST measurement frequencies. UD usually supplies a set of sensitivities which have been obtained by comparison from another accelerometer with a set of algorithmically-smoothed sensitivities derived from those obtained directly from NIST. The smoothing algorithm is consistent with our long experience with Model 8B6 accelerometers in calibration systems.

For running the STD(*) test the test control algorithm is changed so that the system generates the compensated working standard sensitivity at each NIST measurement frequency. The deviation at each frequency from 10.00 pC/g is measured and compared with an acceptable deviation specified in the setup for the STD(*) test.

Whenever a calibration test is initiated, a warning or a prohibition message is displayed if the verification period has expired since the last successful run of the STD(*) test. Also, if the system has not been allowed to warm up for an acceptable period of time, a warning or prohibition message is displayed. Following a prohibition message, the system is returned to the previous menu.

As a security measure, any STD(*) test setup cannot be edited. Parameters such as the system verification period, the warmup time, choice of warning or prohibition messages, reference frequency, working standard reference sensitivity, and other system parameters not frequently changed are found in a menu located through the MAINTENANCE/CONFIGURATION menu. These may also be protected by requiring password entry.

Shaker and Amplifier

Much has already been said about the flexibility of the user-friendly, menu-controlled 400AT/C Digital Calibration Control System. The Models 106AC Shaker and TA100A-C Power Amplifier have been used for over two decades as components of UD transducer calibration systems, and have been periodically improved. The large moving element (3 lb) and force rating (300 lb) allow operation to 100 g with guaranteed low levels of acceleration waveform distortion and transverse motion from 5 to 10000 Hz, with a typical accelerometer as the DUT.

The shaker table moving element has been designed specifically for the calibration applications. The table provides a high resonance frequency and the ceramic insert provides excellent stiffness for back-to-back mounting, excellent coupling to the table, no amplification of transverse motion, electrical isolation of the accelerometer case from system ground, high thermal inertia, and protection of the working standard and its cable mounting connection. See Fig. 5 for an illustration showing the ceramic insert removed from the table. Operation at levels as low as 0.1 g peak is possible because the system may be operated with the blower off at levels less than 15 g. This provides a residual mechanical hum and noise less than .005 g rms.

System Accuracy and Repeatability

A complete discussion of the factors involving system transfer accuracy is very lengthy, particularly when the full frequency range is considered. For the 400AT/C system, factors that affect system accuracy are adjustable amplifier gain accuracy, amplifier frequency response, sweep speed, digital processing effects, transverse motion, temperature variation and system noise. The following discussion will be brief, but will contain comments about each factor.

The major gain ranges for the adjustable amplifier in each channel are calibrated within $\pm$ 0.1% at the reference frequency. The controlled MDAC amplifiers which provide the fine-grain adjustment have a relative accuracy of $\pm$.0125% of full scale, which translates to $\pm$0.125% accuracy at minimum useable gain, at which level the major gain ranges are switched. The algorithm used for assessing the measured sensitivity deviations utilizes the ideal digital gain expressions for both channels and the measured DC output of the differential AC-DC converter so that digital precision is not a factor until the computer interface is considered. The sensitivity difference measurement is transferred with a precision of .025% and the accuracy is $\pm$.025% from the UD370 to the PC AT.

Both measurement channels have identical 3-pole high-pass and low-pass filters, which in combination with the other amplifier measurement electronics provide less than $\pm$0.5% differential response at 2 Hz and 10 kHz. These filters reduce overall noise and temperature transient effects on compression-type accelerometers at low levels and low frequencies.

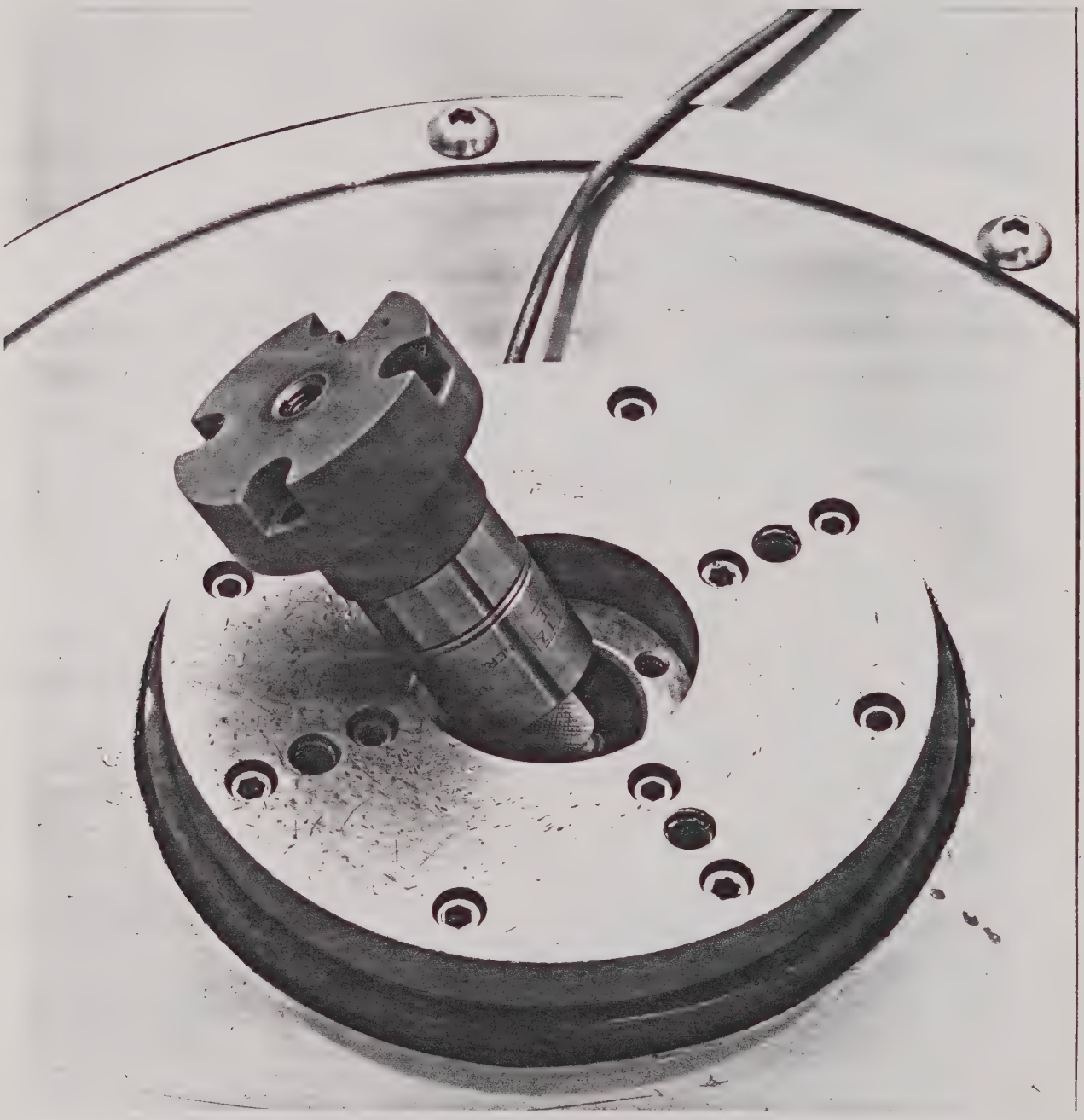


Fig. 5

Ceramic Insert with Working Standard Accelerometer and Removable Outer Plate

At the reference frequency of 160 Hz, transverse acceleration of the Model 106AC Shaker is typically so small it is difficult to measure (<1%), and therefore has a negligible effect on transfer accuracy. At other frequencies, the transverse acceleration is specified. At other frequencies from 5 to 3500 Hz, the error due to transverse motion for typical accelerometers is ±0.2% or less and from 3500 to 10000 Hz the error may be as high as ±1%, but only for several isolated frequencies.

Inaccuracy due to sweep speed effects only occur when the DUT response sensitivity is changing with frequency. A DUT resonance response for which the deviation is approximately 20% exhibits typically 0.1% error for a full range sweep time of 2 minutes.

Transfer errors due to compensating the resonance response of the working standard accelerometer with an electrical network provides less than ±0.5% error between 2 kHz and 10 kHz. Typically this error is ±0.3%.

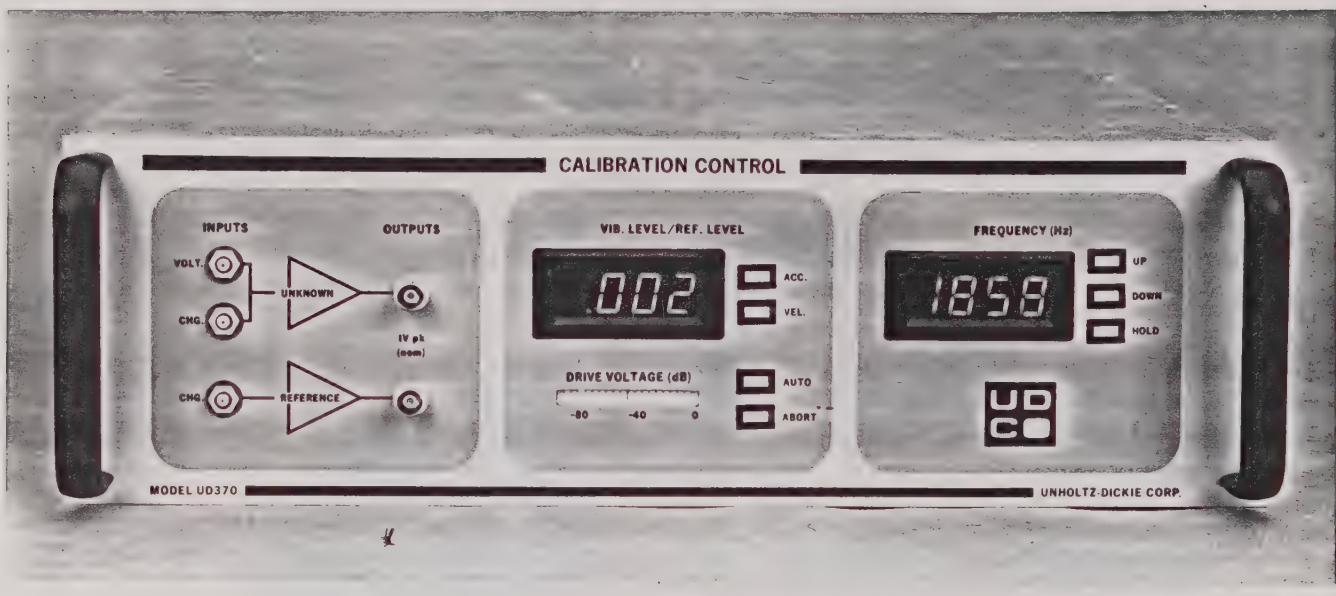
The combined effect of $\pm 3^{\circ}$ C temperature variation at operating temperature for both the 8B6 working standard accelerometer and electronics is estimated to be less than ±0.1%.

Finally, at low levels approaching 0.1 g the system noise and electronic noise can increase the error at the reference frequency to ±0.2%, primarily as a result of increased jitter in the frequency response plot.

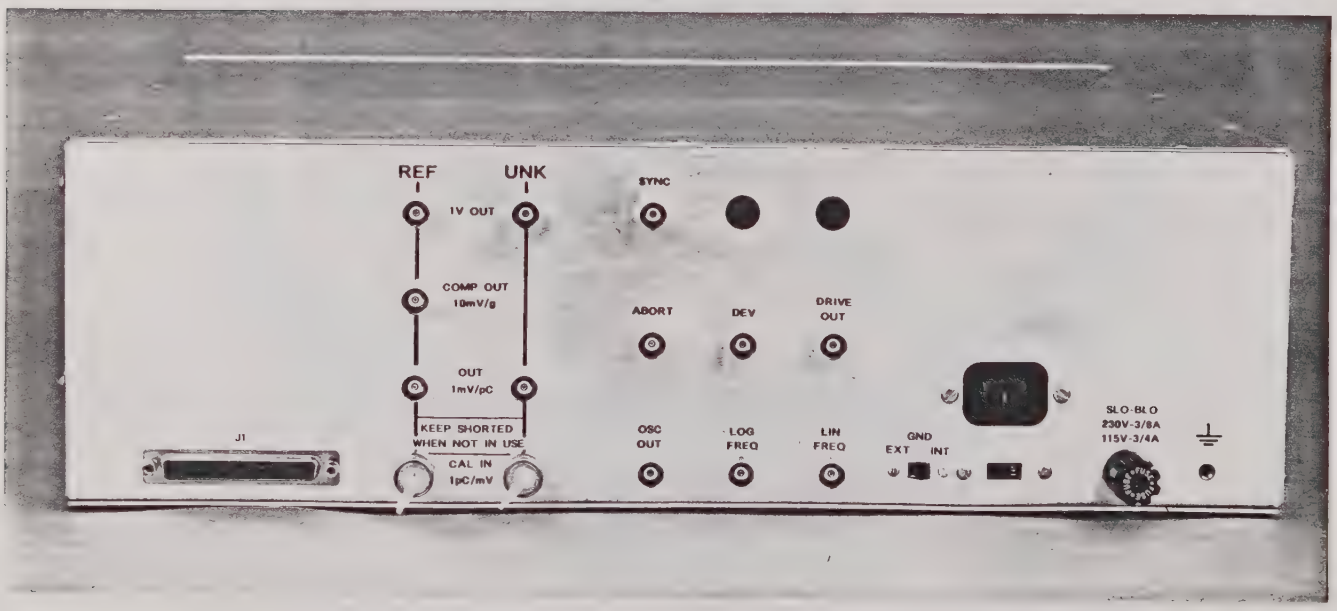
With all effects considered, it is reasonably estimated that the maximum transfer error at the reference frequency is less than ±1.0%. Repeatability of the sensitivity of a DUT by repetitive tests is typically ±0.1% at the reference frequency and within ±0.3% over the entire frequency range.

System Host Flexibility

By exiting from the 400AT/C software the PC AT compatible host computer can readily be used for many other applications for which DOS software exists. Also by installing additional interface cards in the host computer, and optional UD hardware and software, the system may be expanded to provide swept-sine (400AT/S), random (400AT/R) and transient/shock (400AT/T) vibration control.



Front Panel



Rear Panel

Fig. 6

Model UD370 Calibration Control

CALIBRATION CONTROL SYSTEM SPECIFICATIONS
Model 400AT/C Digital Control System
Model 370 Calibration Control System
(See Fig. 6)

1. FREQUENCY

RANGES: 2 to 5000 Hz or 4 to 10,000 Hz.
SWEPT : Single sweep; logarithmic or linear, up or down; 1 to 10 min; starting and ending frequencies selectable over entire frequency range.
STEPPED: As many as 43 selected frequencies over the entire frequency range; precision of settability is .024% of max. range frequecy or .2% of test frequency, whichever is smaller.
MEASUREMENT: 16-bit converter; accuracy is $\pm$.16 Hz for 10 kHz range, $\pm$.08 Hz for 5 kHz range; accuracy is enhanced by averaging at low frequencies during sweep tests and by averaging for stepped-frequency tests.

2. CALIBRATION RANGE

ACCELEROMETERS:
Sensitivities (S) from 0.01 to 10000 pC/g or mV/g;
Reference levels (G) from 0.1 to 100 g pk;
Subject to the restrictions that the product of S and G is limited by

$$1 \leq SG \leq 10000$$

and that the lower end of the frequency range for a given reference level is limited by the velocity and displacement limits of the amplifier shaker system.

VELOCITY SENSORS:
Sensitivities (S) from 0.02 to 10000 mV-s/in;
Reference levels (V) from 0.1 to 50 in/s;
Subject to the restrictions that the product of S and V is limited by

$$1 \leq SV \leq 10000$$

and that the lower and upper ends of the frequency range are determined by the displacement and acceleration limits of the shaker.

3. INPUT CONVERTERS (UD370)

REFERENCE CHANNEL: Charge input from UD Model 8B6 Accelerometer (working standard); internal charge converter compensated to provide 10.00 mV/g sensitivity from 2 to 10000 Hz; Transfer accuracy $\pm$0.5% from 2 to 10 kHz for $\pm$0.1% at reference frequency when compared to Laboratory standard.
VELOCITY INTEGRATOR: Host selection of velocity integrator for reference channel for velocity sensor (DUT) calibration; 10 mV-s/in $\pm$0.5% sensitivity with working reference accelerometer at reference frequency; $\pm$1% response at 5 Hz and 5000 Hz; approx -3dB at 2.5 Hz.

UNKNOWN CHANNEL: Menu-selectable charge or voltage input; internal charge converter 1 mV/pC; gain change less than .025% per 1000 pF source capacitance; unity gain voltage amplifier, input impedance 1000 megohm in parallel with 33 pF; voltage amplifier accepts velocity sensor output also.

POST AMPLIFIERS/FILTERS: Matched characteristics for both channels; individually selectable gain range .1 to 1010; coarse gain adjustment 1.010, 10.10, 101.0 and 1010 ±0.1% (differential ±0.1%); 12-bit controlled fine-gain adjustment 0.1 to 1.0 ±1/2 bit. (±.12 to ±.012%); +0.0, -1.0% response at 2 Hz and 10 kHz (differential ±0.5%); full scale output 1.000 V pk.

CAL IN: Rear panel inputs for both channels with series precision calibration capacitors; 1 pC/mV conversion.

NOISE: .007 pc rms or 7 uV rms RTI + 3 mV rms RTO.

4. OUTPUTS (UD370)

DEVIATION: -2.000 to +2.000 VDC available at rear connector and transmitted to host; sensitivity is 50% deviation/V (-100 to +100% range); accuracy for null reflects accuracy for differential sensitivity and frequency response for REF and UNK channels; 12 bit plus sign conversion to host (±1 bit accuracy);

1 V pk (nom): Front and rear panel connectors for both REF and UNK channels; 1.000 V pk for REF channel at specified control level; 1.000 V pk for UNK channel at specified control level and 0% deviation; provides dual channel waveform display on optional CRO.

1 mV/pC, 10 mV/g: Output for REF and UNK channels at rear panel connectors to assist in calibration.

DRIVE OUT: 50 ohm output impedance; 0-8V rms, servo-controlled, dynamic range > 80dB, distortion <0.2% from 20 to 10000 Hz, (typically 0.04% at reference frequency); internal DC signal through A/D converter provides host with drive voltage amplitude.

OSC OUT: 50 ohm output impedance; 1 V rms ±0.5 dB over entire frequency range; total harmonic distortion 0.2% max, 20-10000 Hz (0.03% typical at reference frequency).

SYNC: Sweep signal for optional CRO providing vibration display of 3 to 4 cycles of REF and UNK channel waveforms regardless of calibration frequency.

LIN. FREQ: DC voltage proportional to frequency (1 mV/Hz).

LOG FREQ: DC voltage proportional to log frequency 0.4V/decade, -.28 VDC(2Hz) to + 1.32 VDC (10 kHz).

5. AMPLITUDE CONTROL

REFERENCE:Constant acceleration or velocity over the calibration frequency range by automatic correction of drive voltage amplitude.
CORRECTION ACCURACY: Essentially zero static error; 70 dB gain change causes less than 0.1% change in control level; dynamic errors reduced by low frequency gain boost.
COMPRESSOR SPEED: Automatically controlled from 10 dB/sec at 2-5 Hz to 3000 dB/sec at 10 kHz.
ABORT LIMITS: Menu selectable upper and lower limits.

6. OPERATIONAL MODES - Selected by single keystroke commands

AUTO: Closed loop operation. DUT sensitivity measured at reference frequency followed by sweep calibration over the range of frequency specified or by stepped-frequency calibration.
MANUAL: Closed loop operation. Following DUT sensitivity measurement at reference frequency, the frequency is determined by the keyboard.
REVERSE SWEEP: Sweep changes direction.
HOLD/SWEEP: Sweep mode toggled between HOLD and SWEEP.
ABORT: Drive voltage smoothly reduced to more than 80 dB below full output.
VOLT/CHG SENS: Following the completion of the swept or stepped-frequency charge or voltage sensitivity calibration, the complementary sensitivity is measured at the reference frequency and the accelerometer capacitance is calculated.

7. TEST STORAGE

CALIBRATION SETUPS: Parameters for individual test setups are entered through the use of prompts and selection menus. Each test setup is usually associated with a particular accelerometer model. Storage for hundreds of test setups is provided on the hard disk.
STANDARDS SETUPS: This special category of test setup is identified by STD as the first three symbols in the SETUP ID. It is used for system verification by comparison of the working standard accelerometer with the laboratory standard accelerometer. Once established, the parameters of this setup cannot be changed.
CALIBRATION DATA: Individual calibration runs may be stored automatically or as selected by the operator. Data for hundreds of calibrations may be stored and recalled for study on hard copy at a later date. Satisfactory data for the last STD* test run is used for system verification.

8. FULL COLOR GRAPHICS AND DISPLAYS

GRAPHS: DUT sensitivity deviation, control level, and drive voltage for swept-frequency calibrations. Keystroke command yields graphical presentation of stepped frequency sensitivity deviation. Keystroke command provides curve smoothing for swept-frequency deviation graphs.

TABLES: DUT sensitivity, deviation, and frequency in column form for stepped-frequency calibration. Keystroke command produces tabular form for swept-frequency calibration following selection of frequencies.

GRAPH AXES: Amplitude and frequency axes completely labeled and may be rescaled by keystroke command. Frequency axis is log or linear with programmable zoom. Deviation may be viewed over any portion of the +100%, -100% range to as small as any 2% segment. Movable cursor for detailed measurements.

ANNOTATION: Calibration Setup ID, Run Name, Manufacturer, Model No., Serial No., additional test description, date, time, display title, percent deviation, test frequency, control level, reference level, reference sensitivity, DUT sensitivity, auto test time, total test time, system status, and sweep time/direction are included around the periphery of the graph or table. DUT sensitivity measurements at the reference frequency are included in upper left corner of graph.

TEXT INSERTION: Added in graphical area by keystroke command.

HELP ACCESS: HELP displays are available on keystroke command to explain details of menu entries and active keyboard commands throughout the test setup and active calibration procedures.

9. FRONT PANEL DISPLAYS (UD370)

VIBRATION METER: 3 1/2 digit 0.56 inch high LED indicates ratio of actual control level to reference level.

FREQUENCY METER: 4 digit 0.56 inch high LED indicates calibration frequency $\pm$ 1 Hz.

DRIVE VOLTAGE: Bar graph indicator - dB relative to maximum output (8 V rms)

LED INDICATORS:

Frequency Sweep:	UP, DOWN, HOLD
Vibration Meter:	ACC., VEL.
Amplitude Control:	AUTO, ABORT

VIBRATION SYSTEM SPECIFICATIONS
Model 106A Shaker
Model TA100A-C Power Amplifier

1. SYSTEM PERFORMANCE (See Fig. 7)

MAXIMUM FORCE: 300 lb peak sine - blower on;
50 lb peak sine - blower off.
FREQUENCY RANGE: 2 to 10000 Hz
DISPLACEMENT: 0.5 in peak-to-peak-standard;
0.75 in p-p with low frequency modification option.
VELOCITY: at least 50 in/s peak except where limited by max. disp. or max. accel.
ACCELERATION: 100g peak with 0.6 lb payload - blower on;
15g peak with 0.6 lb payload - blower off.
TOTAL HARMONIC DISTORTION - STANDARD SYSTEM:
1.5% max, 125 to 10000 Hz at 100g;
typically < 0.5%, 300 to 2000 Hz at 100g;
Isolated peaks between 2000 and 10000 Hz.
1.5% max, 25 Hz to 10000 Hz at 2g.
3.0% max, 10 Hz at 2g
typically < 0.5%, 50 Hz to 2000 Hz.
TOTAL HARMONIC DISTORTION LOW FREQ. OPTION:
1.5% max, 125 to 8000 Hz at 100g;
1.5% max, 8000 to 10000 Hz at 50g;
1.5% max, 10 to 10000 Hz at 2g.
CROSS AXIS MOTION:
5% max (typ 2.5%), 20 to 4000 Hz, 10g, 0.6 lb load;
25% max (isolated peaks), 4000 to 10000 Hz, 10g, 0.6 lb load;
5% max, 20 to 2500 Hz, 10g, 1.0 lb load;
Levels reasonably independent of acceleration level;
Measurements made parallel and perpendicular to trunnion axis.
HUM AND NOISE: Less than .005g rms, blower off.

2. SHAKER (Model 106A)

ARMATURE WEIGHT: 3 lb
AXIAL RESONANCE FREQUENCY:
6700 Hz min - standard;
6000 Hz min - low freq. option; no load.
ARMATURE SUSPENSION: Damped flexures in two planes for radial restraint; rubber flexures in shear for axial restraint.
TABLE DETAILS: Removable centered ceramic flanged insert containing the working reference accelerometer mounted on the inner surface; removable outer top plate provides flush flat surface with flanged insert and a slot for the exit of the reference accelerometer cable above the shaker cover; DUT is mounted on top of ceramic insert; outer top plate may be drilled and tapped to provide attachment holes for transducers not mountable on flanged insert.
MOUNTING: Standard resilient pads under base - 10 to 12 Hz vertical natural frequency; Optional VI-100 isolation - 4 Hz max vertical natural frequency.

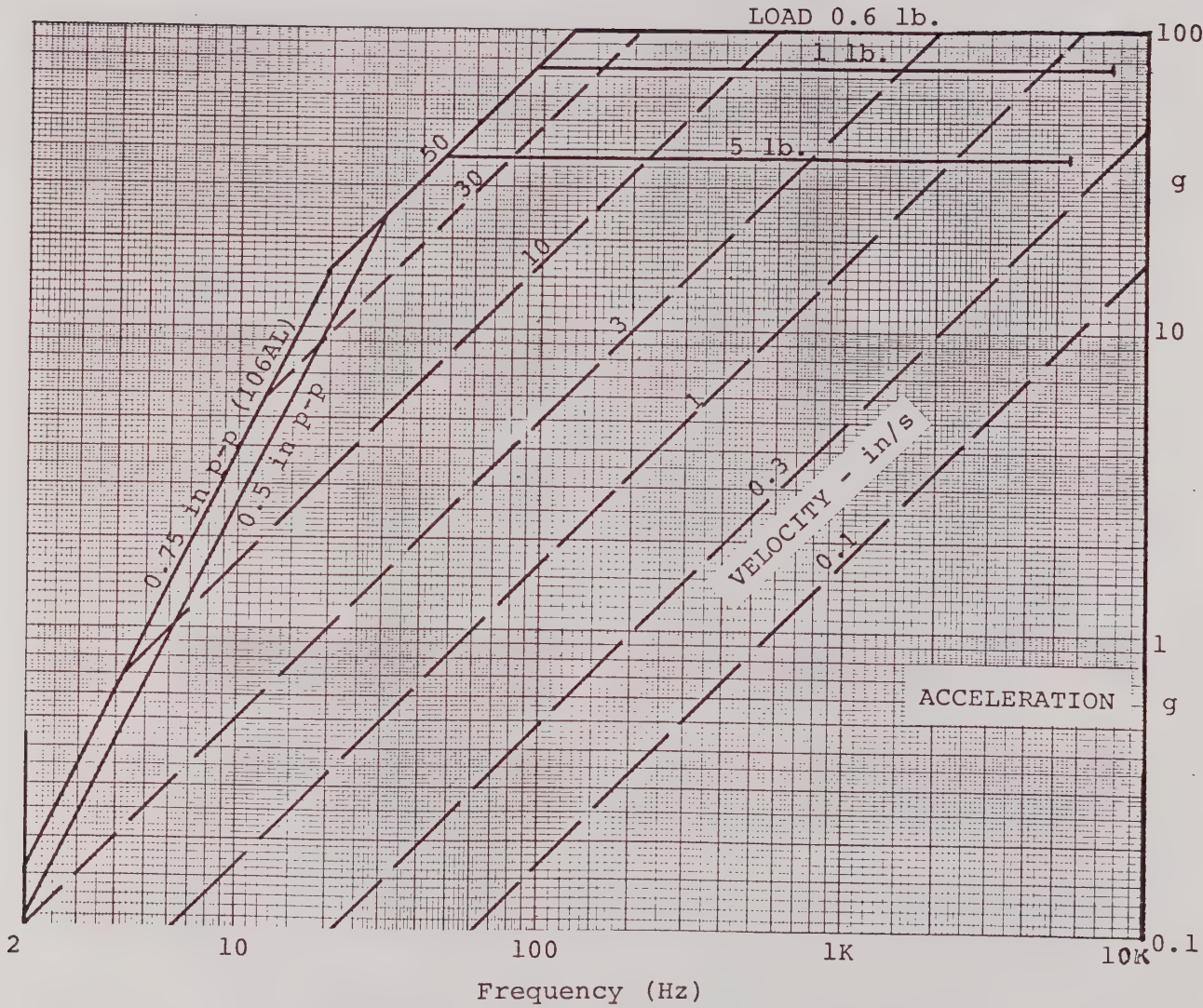


Fig. 7

System Performance

Model 106A Shaker
Model TA100A-C Amplifier

ROTATION: 360° rotation on trunnions with locking.
STRAY MAGNETIC FIELD: Less than 5 gauss 1.0 in. above table top with full field and degaussing coil.
COOLING: Field cooled by clean tap water supplied by customer at <1 gpm; armature coil is air cooled; optional-closed coolant system with forced air heat exchanger for field coil.
PROTECTION: Overtravel switch provides removal of drive signal; energy absorbing mechanical overtravel stops; field coil thermal switch; peripheral seal on table surface and protective cover on shaker precludes entry of foreign material.

3. POWER AMPLIFIER (Model TA100A-C)

GENERAL: Meets all specifications of standard Model TA100A and allows System Specifications to be met with the Model 106AC Shaker and UD370 calibration control. See Bulletin TAA-85.

4. CONTROL CONSOLE

PHYSICAL: Desk type console with writing surface across two 19" bays; writing surface 44" W x 19.25" D; console is 71" H x 45.5" W x 25.5" D, exclusive of writing surface and cooling fan, mounted on casters.
COOLING: Fan on rear door providing filtered forced air; Exhaust fans on upper rear panels.
ELECTRICAL WIRING/CONNECTIONS: All connections and wiring between console components are accomplished within the enclosure, except the signal connections to the optional CRO Monitor. All interconnecting cables from the console to other major system components are terminated with connectors on the console.
DOOR INTERLOCKS: Provide removal of amplifier power when either door is opened.
COMPONENTS:
- Model UD370 Calibration Control.
- PC AT Compatible Host Computer with Dascon Interface.
- VGA Color Monitor with rack mounting kit.
- Dot-Matrix Printer on rack-mounted extendable surface.
- 101-Key Enhanced Keyboard on rack-mounted extendable surface with locking cover.
- System Control Panel(s) with OFF, ON, STANDBY and OPERATE pushbutton switches; field current meter; degaussing current meter; degaussing current control; shaker blower switch.
- Model TA100A-C Power Amplifier.
- Model F90-51 Field Supply, Filter, Degaussing Supply.
- Dual-channel rack-mounted Oscilloscope (Optional).
- Additional space for other instrumentation.

5. CABLES/HOSES

All interconnecting power cables between the shaker, blower and console (15 ft), low noise coaxial cable for the working reference accelerometer (10 ft) and flexible supply and drain water hose (25 ft) between the shaker and plumbing connections are provided by U-D. Water filter and flow controls are provided by the customer, as are all power cables from the electrical utilities to the console.

6. POWER REQUIREMENTS

105-125 VAC, single phase, 1 kVA, 60 Hz (with surge and noise filter in console - additional conditioning may be required for poorly protected single phase sources.)
208, 240 or 480 VAC, 3 phase, 6 kVA, 60 Hz.

210-240 VAC, single phase, 1 kVA 50 Hz
380-415 VAC, 3 phase, 6 kVA 50 Hz

Unholtz-Dickie Corp. maintains a policy of continuous product improvement. These specifications are subject to change without notice.

EQUIPMENT SUMMARY SPECIFICATION
Model 650
Digital Transducer Calibration System

QTY.	DESCRIPTION
1	Model 106A Calibration Shaker including: Model 8B6 Working Standard Accelerometer with 10 ft. low noise cable and mounting stud; A2187-10 Ceramic Table Insert; B2116 Outer Removable Table Plate; BL106 Blower with connecting duct and adapters
1	Model MA650 Control Console, with two 19 in. bays, full width writing surface, cooling fans and rear door interlocks and including: Model UD370 Calibration Control; PC AT compatible HP 286/12 Host Computer with Dascon interface for UD370 and rack-mounting hardware;* VGA Color Monitor, rack-mounted;* Okidata Microline 320 Dot-Matrix Printer with rack-mounted extendable surface;* 101-Key Enhanced Keyboard on rack-mounted extendable surface with locking cover;* Host Configuration and Integration; U-D Licensed Host Software; System Control Panel with OFF, ON, STANDBY and OPERATE pushbutton switches, field and degaussing current meter, degaussing current control and shaker blower switch; Model TA100A-C Power Amplifier; Model F90-51 Field Supply, Filter, Degaussing Supply; Internal interconnecting wiring and interconnecting cables with shaker and blower.
1	Model 8B6 Laboratory Standard Accelerometer with 10' low noise cable, mounting stud and NIST Traceable Calibration Data.

OPTIONS

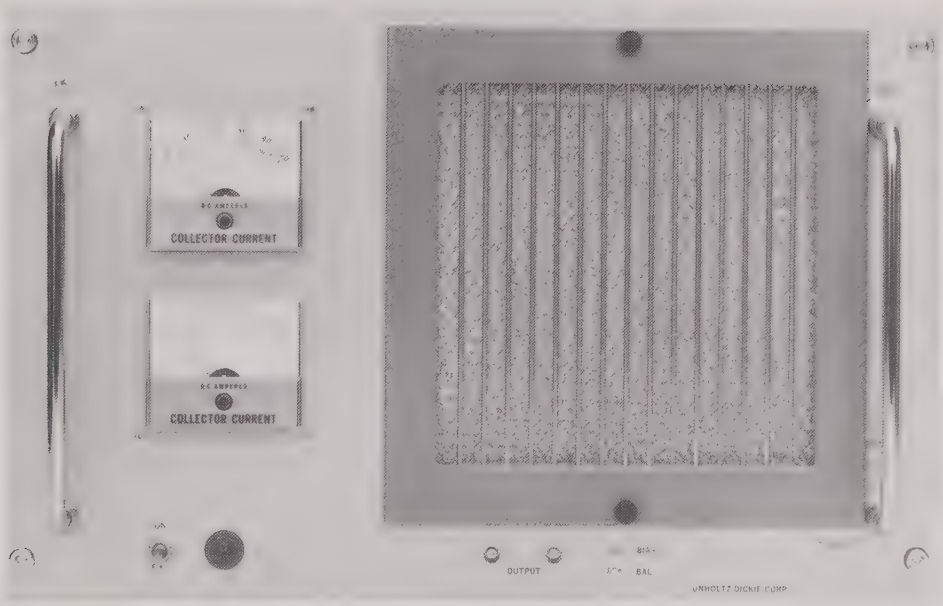
Dual Channel Cathode Ray Oscilloscope;
Low Frequency Option Models 106AL and TA100A-CL for 3/4 in. pk-pk and improved waveform;
Model VI-100 Low Frequency Shaker Isolation.
NIST Calibration for Model 8B6 Laboratory Standard;
HP PAINTJET color printer instead of Okidata 320.

* Unholtz-Dickie Corp. reserves the right to substitute equivalent equipment for the host computer and associated items.

UNHOLTZ-DICKIE CORPORATION

VIBRATION TEST EQUIPMENT

Solid State Power Amplifier TA100A/TA240D/TA250A



- DIRECT COUPLED
- ELECTRICAL LOAD CENTERING
- ULTRA LOW DISTORTION
- OVERLOAD PROTECTED
- LOW VOLTAGE OPERATION
- AIR COOLED
- MODULAR, RACK MOUNT CONSTRUCTION
- TA100A: 1.5 KVA OUTPUT
  TA250A: 2.5 KVA OUTPUT
  TA240D: 2.5 KVA OUTPUT

The Model TA100A, TA240D and TA250A Solid State Power Amplifiers are designed to furnish direct coupled power for electrodynamic shakers, providing output power ratings of 1500 VA and 2500 VA. These amplifiers feature the ruggedness of silicon, stud mount transistors and a mature third generation circuit design with more than 15 years of reliable field history.

DIRECT COUPLED OUTPUT: Major performance advantages are gained by utilizing direct coupling at the output rather than a matching output transformer. Direct coupling makes possible the following desirable operating characteristics: (1) DC electrical load centering which permits full one inch shaker stroke even with heavy test loads; (2) increased shock pulse testing capability by utilizing DC offset of the shaker armature; (3) combined static and dynamic testing; and (4) absence of low frequency transformer roll-off.

Nine basic amplifier configurations are available to provide optimized performance for the following U-D shaker/PA combinations.

AMPLIFIER MODEL	SHAKER	COMMENTS
TA100AF	20	DC field power for shaker taken from P.A. supply. General purpose.
TA100A (CAL) 1/2 TA100A (CAL) 3/4	106A-1/2 106A-3/4	DC to 10 kHz response, special velocity feedback circuitry in "-3/4" model provides ultra-low distortion. Used in U-D calibrators only.
TA100AMI-4 TA250AMI-4C TA250AMI-6	4 4C 6	Includes DC response and selectable current feedback for constant force operation. Calibrated force signal provided. Used only in U-D modal systems. (see separate modal shaker bulletins).
TA250A	20H T110 T206	Standard configuration for 2.5 kVA output. General purpose.
TA250AD	206	Series connection of two TA250A amplifiers provides dual operation at 5 kVA output.
TA240D	560/RTS-5	Series connection of two TA240D amplifiers provides dual operation at 5 kVA output.

SPECIFICATIONS

Power Output:	TA100A: 1500 Volt Amps; TA240D, TA250A: 2500 Volt Amps
Output (Volts/Amps):	TA100A: 45V rms/34 A rms; TA240D, TA250A: 45V rms/56 A rms
Frequency Response:	±0.5 dB 5 Hz to 5 kHz (DC coupling, input to output, provided for modal systems.)
Output V.A.:	Rated output from 5 Hz to 3000 Hz, decreasing to 45% of rated voltage and current at 0.5 Hz and 35% of rated voltage and current at DC with shaker load.
Harmonic Distortion:	5 Hz to 2 kHz < 0.5%, 2 kHz to 5 kHz < 0.7%, with shaker load at full system rated performance.
Hum and Noise:	At least 80 dB below rated output
Output Stage Dissipation:	Transistor rated dissipation is 3.6 kW for TA100A and 6 kW for TA240D, TA250A
Input Impedance:	Over 10 k ohms
Input Signal:	Matched to signal source, 7 V rms typical for full output.
Circuitry:	All solid state
Metering:	Two front panel meters monitor current in each half of the amplifier output stage.
Protective Circuits:	Current limited driver stages prevent overdrive in output transistors. Positive short circuit protection, with fast acting "limitron" fuses. Output stages monitored with peak responding current relays to de-energize the amplifier on overcurrent. Output voltage clipping sensors protect against over voltage. Thermal switches on the output stage heat sink de-energize the amplifier at a conservative 160° F. Amplifier is de-energized if one leg of three phase power is lost.
Zero Set:	Front panel trimpot provides DC centering force at the shaker. Up to ±10% of maximum output is obtainable.
Cooling:	Integral fan draws filtered cool air thru the front of the amplifier. The air filter is removable from the front for cleaning.
Power Requirements:	3 phase, 60 Hz, with taps from 200V to 500V. TA100A requires 3 kVA, and TA240D/TA250A requires 4.5 kVA. 115 volt single phase at 1 amp power is required for fan and interlocks. 50 Hz optional.
Size:	19" rack mounting with 12 1/4" panel height. 19 1/2" depth plus 2 1/2" for cable connection at rear.
Weight:	TA100A, 175 pounds; TA240D/TA250A, 200 pounds.

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Bulletin TAA-85

UNHOLTZ-DICKIE CORPORATION

VIBRATION TEST EQUIPMENT

MODEL 8B6 ACCELEROMETER

FEATURES:

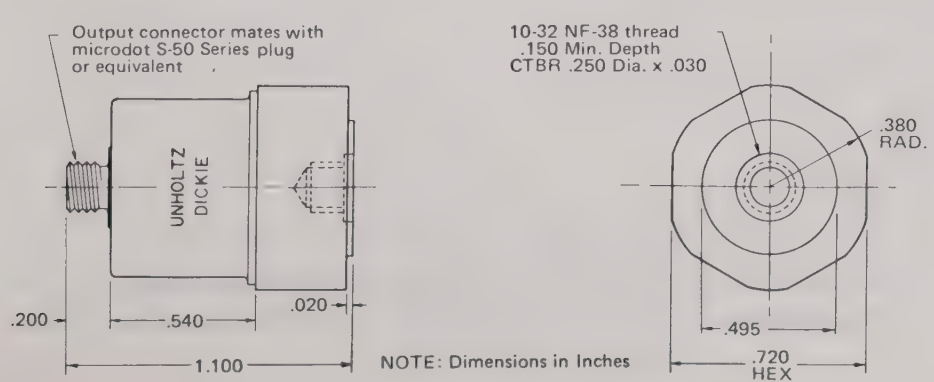
- FLAT RESPONSE FROM -300°F TO +500°F
- 30,000 Hz RESONANT FREQUENCY
- VERY STABLE SENSITIVITY

ACTUAL SIZE

DYNAMIC SPECIFICATIONS

CHARGE SENSITIVITY:	6.0 pC/g, typical
OPEN CIRCUIT VOLTAGE SENSITIVITY:	2.3 mV/g, typical
ACCELEROMETER CAPACITANCE:	2,600 pF, typical
MOUNTED RESONANT FREQUENCY:	30,000 Hz, typical
TRANSVERSE SENSITIVITY:	3% maximum @ 150 Hz
ACCELEROMETER RESISTANCE:	20,000 megohms min @ 75°F 500 megohms min @ 500°F
FREQUENCY RESPONSE:	See Frequency Response Curve
CHARGE SENSITIVITY:	±5%, 1 Hz to **5000 Hz**
VOLTAGE SENSITIVITY, WITH 1000 megohm 300 pF LOAD:	±5%, 1 Hz to **5000 Hz**
AMPLITUDE LINEARITY FOR 2000 g RANGE:	Within 2% of best straight line

The Model 8B6 features a flat charge vs frequency response as well as minimum charge sensitivity variation over a wide range of temperatures. A shaping filter is available in the Model **UD370 Calibration Control** which compensates for the resonant rise of the Model 8B6; the combination frequency response may be held to within ± **0.5** percent from 10 Hz to 10,000 Hz. The accelerometer design is a single-ended compression type with a double base construction to minimize base strain sensitivity. The Bismuth Strontium Titanate ceramic provides excellent sensitivity stability as well as flat temperature response.



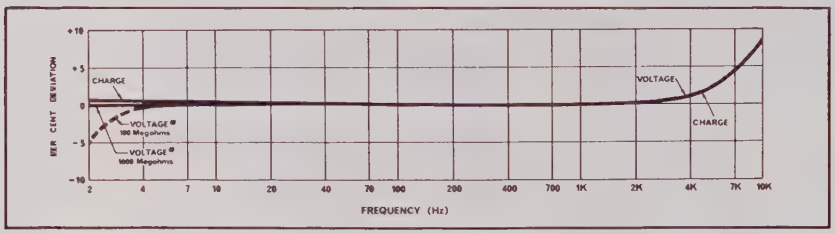
MECHANICAL SPECIFICATIONS

Design Type:	Compression, top connector, grounded case.
Piezoelectric Ceramic:	Bismuth Strontium Titanate
Dimensions (see sketch):	.72" hex, .90" height plus connector
Weight:	1.3 oz (36 gm)
Mounting:	#10-32 thread, .150" deep
Case:	Stainless Steel
Accessories Included:	10 foot high-temp low-noise cable; 10-32 3/8" mounting stud. Insulating adapters available.

ENVIRONMENTAL SPECIFICATIONS

Dynamic Range:	1000 g sinusoidal 2000 g shock
Temperature Range (see Temperature Response Curve):	For ±5% Charge Sensitivity Variation: –300°F to +500°F (–185°C to +260°C) 75°F (25°C) Reference For ±5% Voltage Sensitivity: Variation: –300°F to +350°F (–185°C to +175°C) 75°F (25°C) Reference
Base Strain Sensitivity:	Equivalent .05g/μin/in typical, measured per ISA RP37.2
Thermal Shock Sensitivity for 10°F Step Input:	Equivalent 0.2 g/°F, typical with 2 Hz high pass filter
Acoustic Sensitivity:	0.1 g rms @ 100 dB broadband, typical
Altitude:	Not affected

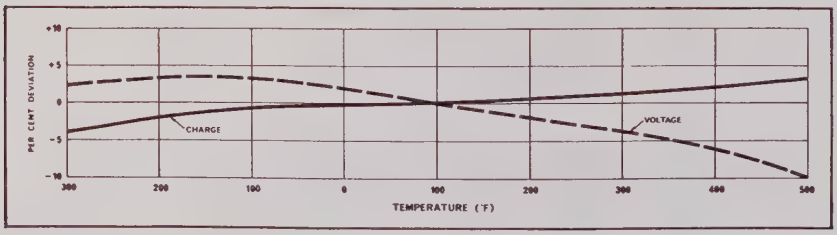
FREQUENCY RESPONSE (Typical)



NOTE:

Voltage frequency response is shown for a load capacitance approximately 300 pF at room temperature.

TEMPERATURE RESPONSE (Typical)



NOTE:

Variation of sensitivity with temperature is shown at 100 Hz.

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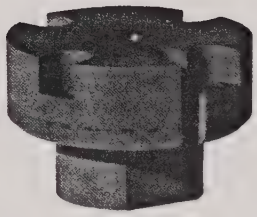
Bulletin 8B6-88

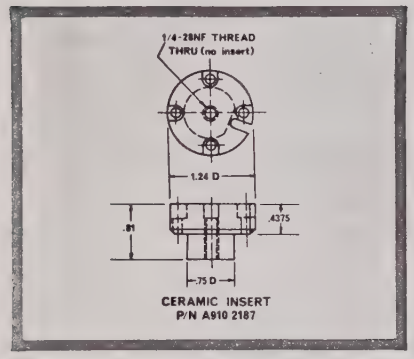
CERAMIC CENTER INSERT

FOR COMPARISON CALIBRATIONS

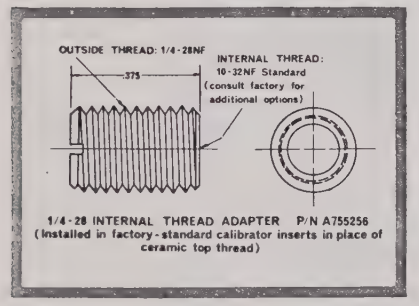
This ceramic insert offers improved back-to-back comparison type accelerometer calibrations. The ceramic material combines high stiffness with excellent electrical isolation of the accelerometers from the shaker and from each other. This isolation eliminates any possibility of error from ground loops and avoids the use of isolating studs which may affect the frequency response at high frequencies. Compliance between the test and reference accelerometers is reduced and high frequency comparison accuracy is improved because of the high stiffness of the ceramic material.

This insert is designed for use with current Model 106A calibration shakers and with comparison bridges to be mounted on other shaker models.





CERAMIC INSERT
P/N A910 2187



1/4-28 INTERNAL THREAD ADAPTER P/N A755256
(Installed in factory-standard calibrator inserts in place of ceramic top thread)

FEATURES AND SPECIFICATIONS

1. Modulus of Elasticity: 46×10^6 psi
2. Resistivity: 2×10^{14} ohm cm
3. Weight: 1.3 oz (36gm)
4. Standard Top Thread: 10-32 NF, stainless steel (.350" min depth from 1.24"D surface)
5. Standard Bottom Thread: ¼-28 NF, ceramic (.350" min depth from .75"D. surface)

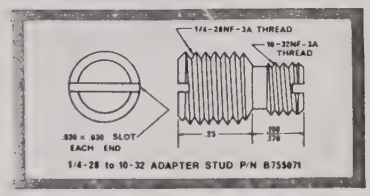
The factory-standard ceramic calibrator insert (P/N 910-2187-10) has the P/N A 755256 Internal Thread Adapter installed to reduce the top thread to 10-32 NF from ¼-28 NF and to provide stainless steel threads in place of ceramic threads for greater durability of the more frequently used mounting thread.

The ceramic insert is also available without the stainless steel internal thread adapter for those applications which require a ¼-28 NF top mounting thread. Use of this version (PN 910-2187) requires that greater care be used when mounting and torquing accelerometers since the top mounting threads are ceramic and not stainless steel.

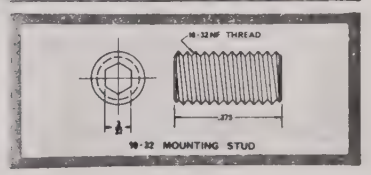
Additional top thread adapters are available on special order for additional thread sizes. Please consult factory for details.

PART NO.	TOP THREAD	BOTTOM THREAD	ACCESSORIES SUPPLIED
910-2187-10	10-32 NF Stainless Steel	1/4-28 NF Ceramic	755071 Adapter (1) 10-32 Mtg stud (1)
910-2187	1/4-28 NF Ceramic	1/4-28 NF Ceramic	755071 Adapters (2)
Consult Factory for additional options.			

ACCESSORY STUDS



1/4-28 to 10-32 ADAPTER STUD P/N B755071



10-32 MOUNTING STUD

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Vibration Testing Equipment

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TELEX #643802 UD CORP WFOD

WEST COAST OFFICE: (213) 316-0275
1924 SOUTH PACIFIC COAST HWY-SUITE F
REDONDO BEACH, CA 90277

WARRANTY

Digital controllers and associated options are warranted to be free of defects in material and workmanship for a period of 90 days from date of shipment (Extended Coverage available).

All other products are warranted to be free of defects in material and workmanship for a period of one year from date of shipment. If the products are not installed, maintained and used in a normal manner in accordance with instructions and manuals, this warranty will not apply.

This warranty is limited to repairing and replacing parts which have been returned to UNHOLTZ-DICKIE CORP., and in our opinion are defective. Service required to correct defects in material or workmanship will be supplied without charges. The Buyer will pay all transportation and taxes incurred. This warranty does not cover costs incurred by the Buyer as a result of purchase of UNHOLTZ-DICKIE CORP. equipment or any charges for the Buyer's labor for replacement, adjustment or repair unless authorized in advance in writing. We are not liable for consequential damages.

This warranty will not apply to any products which, in the opinion of UNHOLTZ-DICKIE CORP., have been subject to accident, misuse or neglect; altered or repaired with a substitute which might impair the product; or used outside of rated conditions. UNHOLTZ-DICKIE CORP. reserves the right to make improvements in its products including changes and additions without incurring obligations to incorporate such improvements in previous units.

This warranty is expressly in lieu of any and all other warranties or commitments, expressed or implied and any other obligations to the Buyer associated with the use of UNHOLTZ-DICKIE CORP. products.

02-13-86

MP MASTER

MA34559

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